Changes in Noncondensable Gases in Steam from the Cerro Prieto Geothermal Field

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RESEARCH OBJECTIVES

Changes in CO_2 content and nitrogen/argon (N_2/Ar) weight ratios in the steam produced by wells from the eastern parts of the Cerro Prieto geothermal field of Baja California, Mexico, were studied to determine the effects of the main active processes in the reservoir (i.e., boiling, condensation, groundwater recharge, and mixing) on the gases contained in the steam.

APPROACH

Comprehensive data sets have been collected on this >300ºC liquid-dominated geothermal field since the beginning of the exploration phase of the project in the late 1950s. Electricity began to be produced in 1973. Chemical and production data for the period 1990–2000 were analyzed and plotted to determine changes in the distribution of CO_2 concentrations and N_2/Ar values with time. Only the physical aspects of the reservoir gases were studied, mainly in connection with earlier work on solute chemistry and enthalpy of well discharges.

ACCOMPLISHMENTS

The results of this study agree in general with our earlier understanding of the response of the Cerro Prieto reservoir to pressure drawdown due to large mass extraction rates. (About 14,000 tons/hour are extracted and some 3,500 tons/hour are injected back into the reservoir.) In areas of boiling, production enthalpy increased greatly, and CO_2 content in steam increased two to three times. Nitrogen/argon ratios remained near that of air-saturated surface waters, but were lower in areas where boiling decreased and where production originated from gas-depleted brines residual to boiling. Newly drilled deeper wells also produced steam that was low in gas and N_2/Ar ratios, suggesting that these zones were also affected by boiling and gas loss. Injection of highly evaporated, air-equilibrated brine seemed to have little effect on the gases in the steam. There is evidence of a 1990 short-term, high N_2/Ar anomaly in the eastern part of the field (Figure 1), possibly from injection of air with the residual brine. There is also evidence that in 1995 and 1996, the northeastern region of the field produced steam with much higher N_2/Ar ratios, perhaps reflecting a bubble of altered magmatic gas that entered the system at depth.

SIGNIFICANCE OF FINDINGS

The results show that it is possible to identify reservoir processes by studying the chemical and physical response of wells to large-scale exploitation. These studies are valuable for anticipating changes in fluid production behavior. The information helps design appropriate changes in the field management plan that may reduce any future negative impact on the field's energy output. This is especially true at Cerro Prieto, since its electricity output satisfies the needs of about a million people (the present installed capacity is 720 MW). The work also seems to indicate that bubbles of magmatic gas are injected periodically into the geothermal reservoir as part of the recharge mechanism of the system. This hypothesis warrants further study.

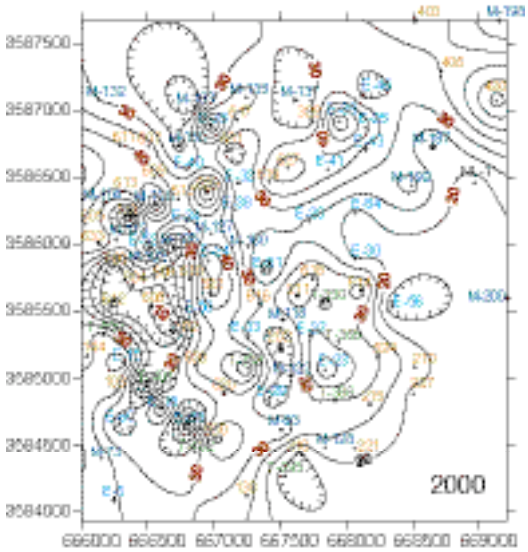

Figure 1. Nitrogen/argon weight ratios in geothermal steam produced by eastern Cerro Prieto wells for the years 1990, 1995, and 2000. The shaded area corresponds to the intersection of the main fault in the field (normal Fault H) with the top of the deeper reservoir (Beta Reservoir) (distances in meters).

RELATED PUBLICATIONS

Lippmann, M.J., A.H. Truesdell, M.H. Rodríguez, and A. Pérez, Response of Cerro Prieto II and III to exploitation. Geothermics, 2003 (in press).

Truesdell, A.H., M.J. Lippmann, M.H. Rodríguez, and A. Pérez, Influence of reservoir processes on gas in Cerro Prieto steam. Geothermal Resources Council Trans., 27, 2003 (in press); Berkeley Lab Report LBNL-53499.

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